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AN/TSQ-84 UPGRADED COMPONENTS. (U)
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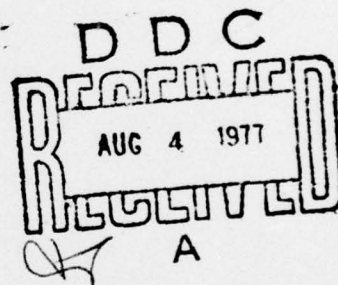


Research and Development Technical Report
ECOM-74-0472-F

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AN/TSQ-84 UPGRADED COMPONENTS

R.H. GEIST
STELMA Telecommunications
Dataproducts
Wallingford, Connecticut 06492



Final Report for Period July 1974-December 1976
FEBRUARY 1977

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SECTION I

INTRODUCTION

1.1 GENERAL

The Communications Technical Control Center AN/TSQ-84 is an air- or vehicular-transportable assemblage designed and built by the Tobyhanna Army Depot as an integral part of ATACS (Army Tactical Communications System). ATACS is an integrated system of communications equipments providing secure and non-secure, high quality transmission paths, circuits and message switching, and the means to terminate and control these circuits and paths. Many different components have been engineered into basic functional configurations identified as communications assemblages. These assemblages provide the transmission paths, switching centers and terminal equipments providing command and control communications for and between the various levels of Command from Brigade to Corps.

Serving the Technical Control function, the AN/TSQ-84 provides the capability to manually interconnect, monitor, and test the large number of communications circuits patched and terminated at Signal Centers in ATACS. It interfaces local subscribers via Automatic Switch Assemblage AN/TTC-38 with the VF side of associated radio multiplex equipment for long distance transmission.

To fully appreciate the mission of the AN/TSQ-84 and the subsequent decision to upgrade its capabilities, (i.e., create the AN/TSQ-84A) it is necessary to first understand what the Technical Control function is and what the duties of Technical Control personnel are.

1.2 TECHNICAL CONTROL FUNCTIONS

Technical Control is considered the "heart" of a communications system through which the "arteries" of communications pass to the users. The efficiency with which Technical Control actions are performed determines the quality and quantity of communications service. A Technical Control facility must contain jack fields in which every circuit passing through the facility can be accessed for monitoring and testing, or for patching to reroute any circuit. It must also contain the test equipment required to monitor and test a circuit and, if necessary, line conditioning equipment which can be used to compensate for various characteristics of the transmission media which tend to degenerate the signal. With this equipment at his disposal, the Technical Controller must maintain efficient communications between the users and/or transmission links within the area of his responsibility.

1.3 TECHNICAL CONTROLLER DUTIES

The primary responsibility of the Technical Controller is to maintain quality and continuity of communications by taking appropriate action in accordance with established Technical Control procedures to prevent or correct conditions adversely affecting his operation.

The Technical Controller ensures quality and continuity of the communication links by the following:

- (1) Tests operation of various circuits to ensure high quality operation and maximum efficiency.
- (2) Verifies quality of reception on communications circuits by use of teletypewriter equipment, patch panels, and communications test equipment.
- (3) Uses test devices such as signal generators, meters, and distortion analyzers in conjunction with monitor aids to analyze circuit conditions.
- (4) Determines overall circuit conditions from test results and observations of these factors.
- (5) Applies established procedures using voice or teletypewriter order wires, in coordination with associated local and distant facilities, to effect necessary operational adjustments on line conditioning equipment.

- (6) Coordinates with local facilities and distant station Technical Controllers and conducts tests to locate source of trouble.
- (7) Evaluates test results and factors involving interruptions, failures, or disturbances resulting from such situations as atmospheric storms, equipment failures, etc., and takes appropriate corrective action such as substitution of equipment or establishing reroutes to maintain the communications link.
- (8) Accomplishes special operational performance tests and/or evaluation of new equipment and circuits.
- (9) Maintains continuous knowledge of facilities available for rerouting.
- (10) Maintains required logs and records and provides data for preparation of pertinent reports.

In essence then, the Technical Controller exercises the functions of all the equipment at his disposal to monitor, test, and if required, patch any circuits within his area of responsibility. In addition, he is also responsible for performing all the required record keeping and updating of logs which are an extremely important facet in maintaining maximum efficiency of the Technical Control facility.

1.4 SHORTCOMINGS OF ORIGINAL AN/TSQ-84

As originally conceived, designed, and built, the AN/TSQ-84 was capable of performing its mission within ATACS to control 864 4-wire VF circuits and 48 full-duplex telegraph circuits. It contained all the jack-fields which provided the necessary access to perform monitoring, testing, and patching of every circuit routed through the shelter, test equipment (oscilloscope, telephone test set, and telegraph test set) required to perform testing and monitoring of signals, line conditioning equipment (attenuators) which enabled signal level changes necessary to effect an interface with associated communications systems, telegraph line isolation and terminating equipment, telephone signal converters, etc.

Through subsequent evolution, the dc circuits and the associated isolators and terminals were removed from the shelter, the telephone signaling conversion function was moved to the AN/TTC-38 shelter, and line amplifiers and line equalizers were installed as additional line conditioning equipment.

In both of these configurations, the Technical Controller's job was accomplished in essentially the same manner. All testing and monitoring was performed by manually patching a particular item of test equipment to either a bridging or break type jack associated with the specific circuit being checked, and the station records and daily logs were updated by manual bookkeeping methods.

With the amount of circuits being handled by the AN/TSQ-84, it soon became apparent that all of the manual tasks required of the Technical Controller were becoming an undue burden and interfering with his job efficiency. Consequently, in 1972 the ATACS Project Management Office directed the Tobyhanna Army Depot to prepare two AN/TSQ-84 shelters to accept automated Technical Control Equipment. Testing and evaluation of these upgraded shelters was to be done under supervision of ECOM, Fort Monmouth. A contract was subsequently awarded to STELMA, Inc. of Stamford, Connecticut to design and install the automated equipment in both shelters. The first shelter was completed and delivered in July, 1976 and the second in October, 1976. Testing and evaluation of both shelters (redesignated AN/TSQ-84A) is to be accomplished early in 1977 at Fort Huachuca. Depending upon this evaluation an additional 25 shelters may be upgraded in the same manner.

SECTION II

PHYSICAL AND FUNCTIONAL DESCRIPTION

2.1 INTRODUCTION

The AN/TSQ-84A is an improved version of the original AN/TSQ-84 shelter. The improvement is in terms of the upgraded components which were added by STELMA Inc. under contract DAAB07-74-C-0472 to the original shelter to give it added flexibility. The existing shelter has manual record-keeping and patch panel technology that has been used successfully for many years in previous Technical Control facilities with fewer lines. However, the advent of the AN/TTC-38 Automatic Switch caused the number of lines to increase dramatically and the Technical Controllers job became extremely difficult. The objective of upgrading the existing shelter was to lessen the work load on the operator and permit more efficient use of the shelter as a Technical Control Center.

The function of the Technical Controller is to perform the following six basic tasks:

- Monitoring
- Testing
- Patching
- Line Conditioning
- Reporting
- Record Keeping

It became apparent that with the increased number of circuits to be handled by the AN/TSQ-84A it would be very difficult for a single operator to efficiently perform all six tasks. The answer was to provide assistance in the form of automation to assist the operator in performing these tasks. The upgrade was designed to help in the performance of these tasks in two main areas: (1) assisting the operator in accessing the lines for test or monitoring, (2) providing a computerized record keeping system to assist the operator in storing information and reporting that information as necessary.

2.2 PHYSICAL DESCRIPTION

The upgrade components are referred to collectively as the Automatic Monitor and Test Equipment which are housed in four major assemblies: a Display Rack and Printer Rack Assemblies (which are joined to form a single console, as shown in Fig. 1), a Signal Matrix Assembly, and a Line Conditioning Matrix Assembly. The following paragraphs provide more detailed description of the equipment.

2.2.1 Console

2.2.1.1 Telephone Test Set AN/USM-181(*). Telephone Test Set AN/USM-181, the uppermost unit in the Display Rack Assembly, is government furnished equipment (GFE).

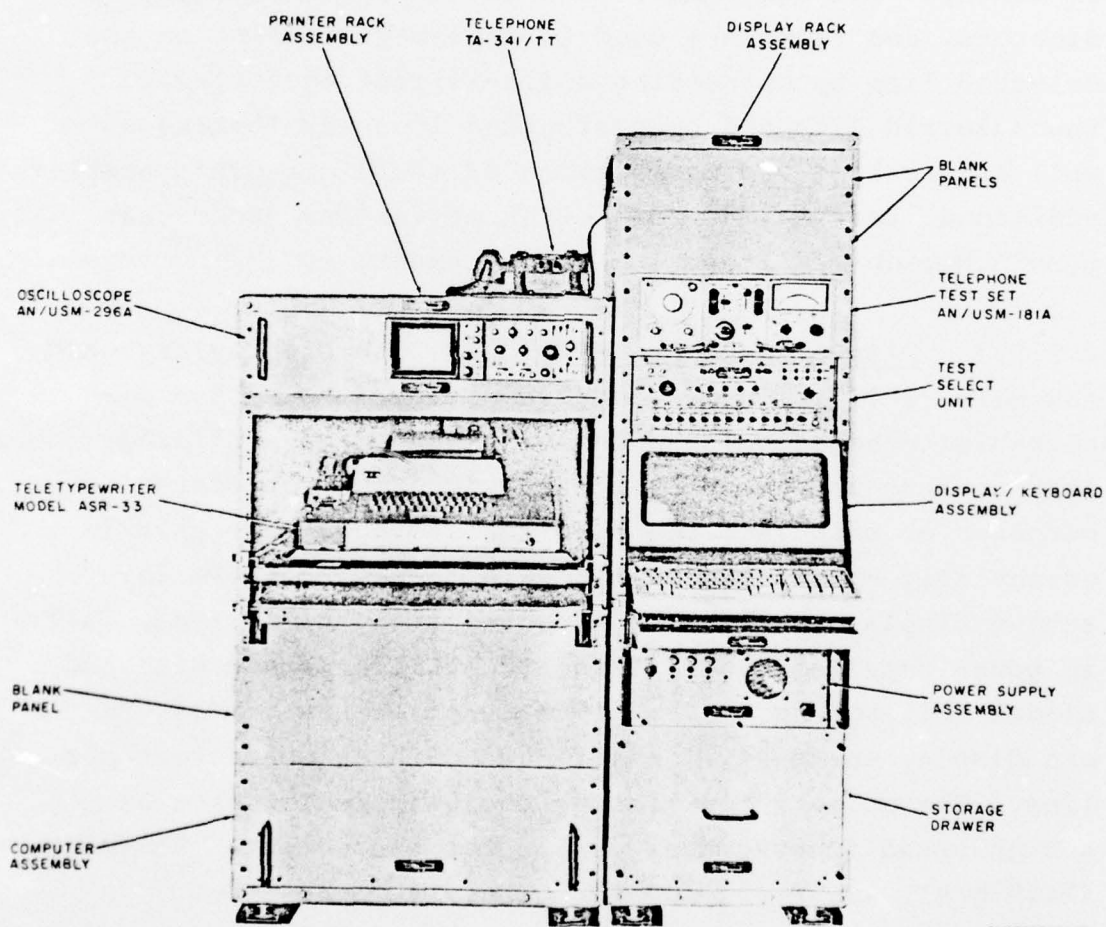


Figure 1. Operators Console

2.2.1.2, Test Select Unit. Mounted below the Telephone Test Set AN/USM-181 is a Test Select Unit. The Test Select Unit houses seven PC cards and a hinged front panel which contains various switches, indicators, and jacks. Five of the PC cards are contained in an RFI enclosure within the nest and serve as the interface between the Computer and the Matrix for selecting a specific line for test. The other two PC cards are used in the selection of certain test equipment. The front panel switches, indicators, and jacks are used to implement testing on the selected line by connecting built-in test equipment to the selected line and by performing loopback testing as well as breaking and terminating of the line. This enables additional testing and connection of various jacks that permit hookup of external test equipment.

2.2.1.3 Display/Keyboard Assembly. The Display/Keyboard Assembly (CRT Terminal) comprises a CRT display and detachable keyboard which are shock mounted on a sliding tray so that the assembly can be withdrawn for operating purposes or slid into the rack for storage. The unit is essentially an off-the-shelf Hewlett Packard 2640A Interactive Display Terminal. It contains eight PC cards, built-in power supplies, and a standard ASCII keyboard with additional editing and control-type function keys. The CRT can display up to 24 lines of data with 80 characters per line. The primary function of the unit is to serve as a high-speed input/output device for the Computer Assembly (2400 b/s).

2.2.1.4 Power Supply Assembly. Operating voltages for the PC cards in the Test Select Unit are provided from the Power Supply Assembly. The assembly contains three dc power supplies, each equipped with a separate overvoltage protection device. The hinged front panel contains input and output power fuses, output test points, and a loudspeaker that is used in conjunction with a Speaker-Amplifier PC card located in the Test Select Unit. A dc power output plug, mounted on the front panel, provides operating voltage for a Matrix Card Test Set used at the Organizational maintenance level.

2.2.1.5 Telephone TA-341/TT. Telephone TA-341/TT, mounted on top of the Printer Rack Assembly, is GFE.

2.2.1.6 Oscilloscope AN/USM-296. Oscilloscope AN/USM 296, mounted in the top shelf of the Printer Rack Assembly, is GFE.

2.2.1.7 Teletypewriter Model ASR-33. Teletypewriter ASR-33 is shock-mounted on a sliding work shelf located below the AN/USM-296. It is an off-the-shelf Teletype Corp. unit with some minor modifications. Its enclosure within the Printer Rack Assembly is lined with sound absorbing material for quiet operation. Mounted on the rear of the ASR-33 is a Motor Control Unit which turns off the teletypewriter motor if no data is received within five minutes. The unit also includes a paper tape punch and tape reader. The primary function of the ASR-33 is to serve as a low-speed input/output device (110 b/s, ASCII) for the Computer Assembly.

A modification incorporated into the ASR-33 enables it to be operated in conjunction with the Computer. The principal component in the modification is a PC card that is mounted on the ASR-33 call control unit.

2.2.1.8 Computer Assembly. The Computer Assembly, (an AN/UYK-19(V) with options selected specifically for application in the AN/TSQ-84A), operating under program control, serves as the hub for all data processing activities in the Automatic Monitor and Test Equipment. Housed in the bottom compartment of the Printer Rack Assembly, the entire assembly is slide-mounted so that it can be pulled out of the rack and made accessible for maintenance. The assembly consists of a main frame, which houses 22 PC cards, and a Control Panel. Included in the main frame are two sets of four PC cards which serve as the core memory. Each set provides 8192 words of storage; thus the entire core memory has a 16,384 word capacity (16-bits per word).

2.2.2 Signal Matrix Assembly.

The Signal Matrix Assembly comprises a four-foot relay rack (remaining from the original AN/TSQ-84) which houses two PC card nests each containing 18 identical Matrix PC cards (total 36 PC cards). Each PC card contains 12 C-form relays and 12 A-form relays. The A-form relays allow connection of bridging type test equipment (via the Test Select Panel) to any one of the 432 normal-through VF circuits; the C-form relays are used to break any one of the VF circuits for the purpose of termination or loop-back testing.

2.2.3 Line Conditioning Equipment Matrix Assembly.

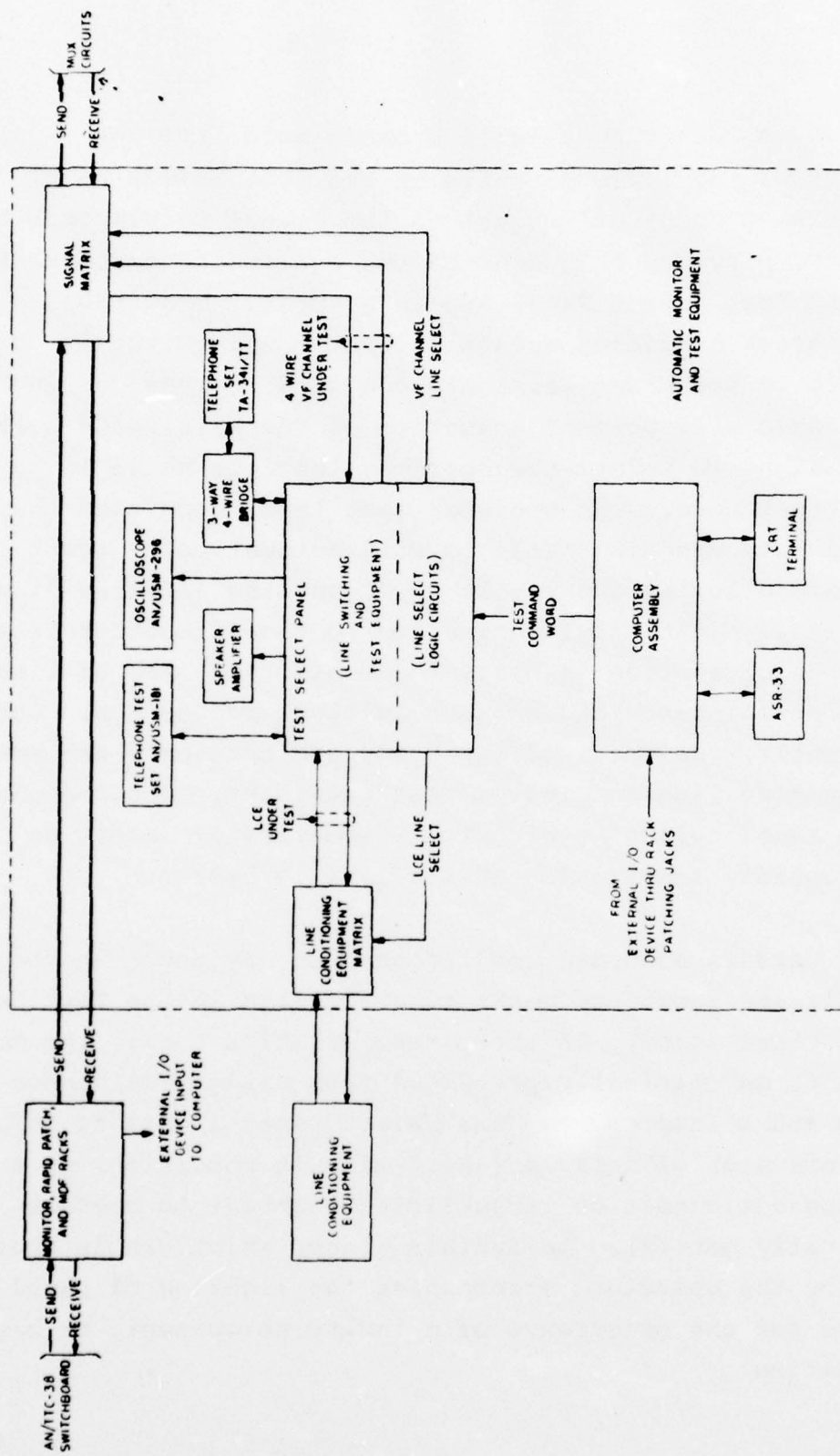
The Line Conditioning Equipment Matrix Assembly (located on the roadside wall behind MDF 1) houses seven Matrix PC cards identical to those in the Signal Matrix Assembly. These PC cards also serve the same function as the PC cards in the Signal Matrix (i.e., bridging or terminating a line under test) except that the lines routed through the Conditioning Equipment Matrix Assembly are those connected directly to Line Amplifiers, Line Equalizers, and Attenuators.

2.3 FUNCTIONAL DESCRIPTION

2.3.1 Overview (Fig. 2)

The 432 4-wire VF circuits entering and leaving the shelter are represented as a single send-receive circuit pair. All VF circuits are normalled-through the Monitor, Rapid Patch, and MDF racks and all pass through the Signal Matrix where each may be individually accessed for testing and/or monitoring. A separate Line Conditioning Equipment (LCE) Matrix permits selection of any one of the line conditioning equipments in the MDF racks (Line Equalizers, Line Amplifiers, and Attenuators) for individual testing. The functions of the Signal Matrix and the LCE Matrix are mutually exclusive; it is not possible to test a 4-wire VF circuit and a line conditioning equipment at the same time.

Operationally, a 4-wire VF circuit or a line-conditioning equipment are each accessed for monitor or test in basically the same manner. The operator enters the appropriate request on either of two keyboards (ASR-33 or CRT Terminal). The Computer Assembly examines the request, determines its validity and, if valid, issues a test command in the form of a 16-bit parallel data word to the logic circuits in the Test Select Panel. If the operator's request is invalid the computer returns an "invalid request" message to the input device and waits for another request.



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Figure 2. AN/TSQ-84A Upgrade Components, Block Diagram

Upon receiving a valid command word from the computer, the logic circuits in the Test Select Panel generate a "connect" signal to the Signal Matrix or LCE Matrix, provided that none of the equipment select switches on the Test Select Panel are in a "break" condition. If a break condition exists (a test panel switch is positioned to break and terminate the send or receive line), the logic will prevent actuation of the matrix and a lamp will light to inform the operator that the panel is in the break mode. The operator must then reposition the panel switches and the logic will automatically reset itself, allowing the matrix to access the selected line for test. Initially, connection to the line under test is made on a bridging basis for monitoring; the VF line remains uninterrupted between Switchboard and Mux. Subsequently, the operator may break and terminate the send or receive line and insert test equipment. The Test Select Panel switching circuits automatically insert an appropriate termination when a line is broken.

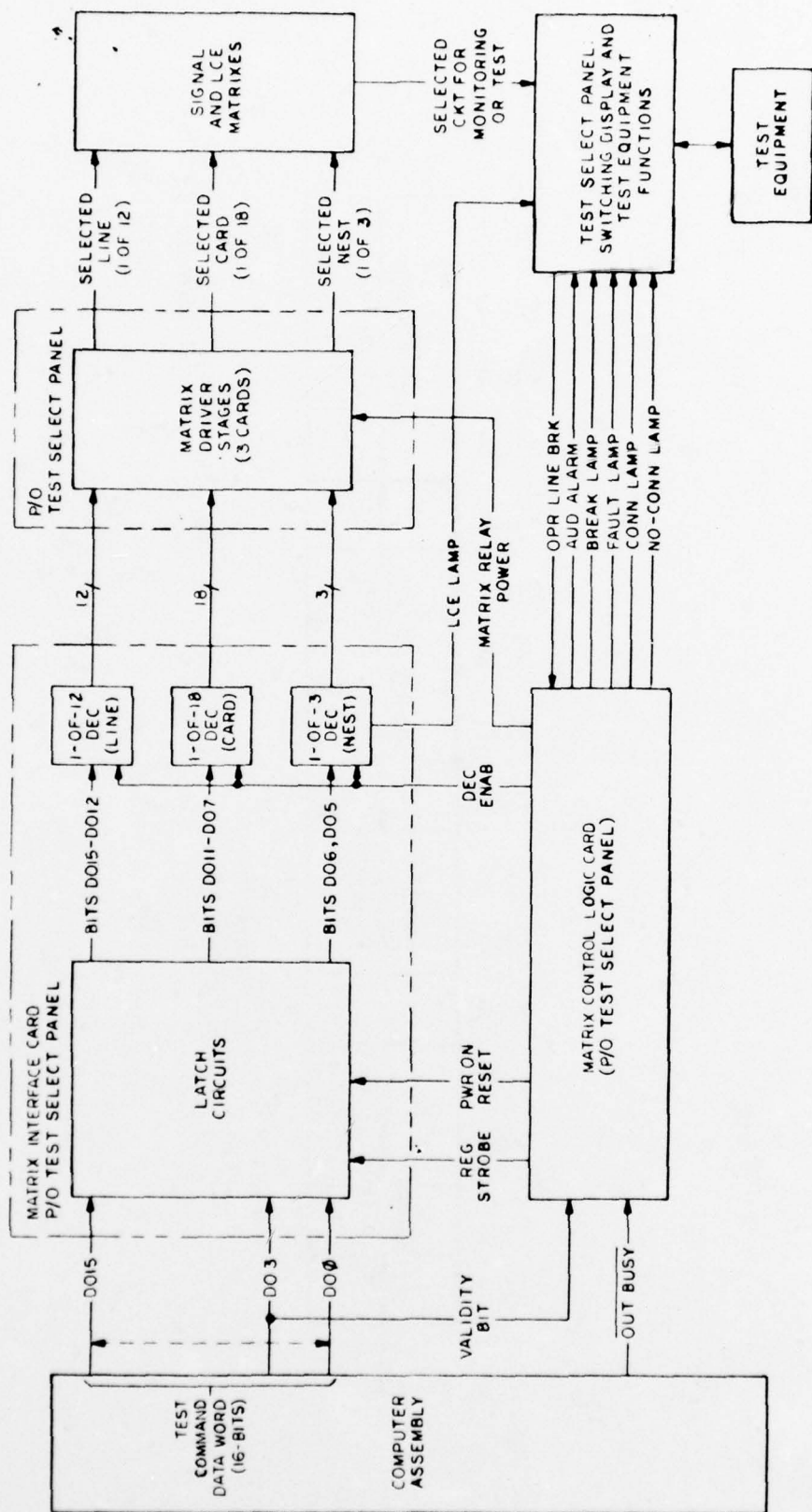
Certain abnormal conditions that may occur in the matrix are sensed by monitoring circuits in the Test Select Panel logic. If these abnormalities occur, the matrix is automatically prevented from making the connection and a lamp on the Test Select Panel lights to inform the operator of a fault (short-circuit condition) or a no-connect condition (insufficient current to operate the relay matrix). An audible alarm, which can be shut off by the operator, accompanies the lighting of panel lamps for the occurrence of a fault, no-connect, or break condition.

Connections between the Oscilloscope or Telephone Test Set and the circuit under test are made via jumper cables to connectors on the Test Select Panel. The Speaker Amplifier monitoring circuit is part of the Test Select Panel; the associated loudspeaker is mounted remotely (in the front panel of the Power Supply Assembly). This audible monitoring capability is controlled by a switch and volume control on the Test Select Panel. The 3-Way/4-Wire Bridge is also part of the Test Select Panel and operates in conjunction with Telephone TA-341/TT located on top of the Printer Rack Assembly. The 3-Way/4-Wire Bridge is controlled by switches on the Test Select Panel. It allows 3-way communication between the Switchboard, operator, and Mux, or 2-way communication between the operator and either the Switchboard or Mux.

2.3.2 Detail Description

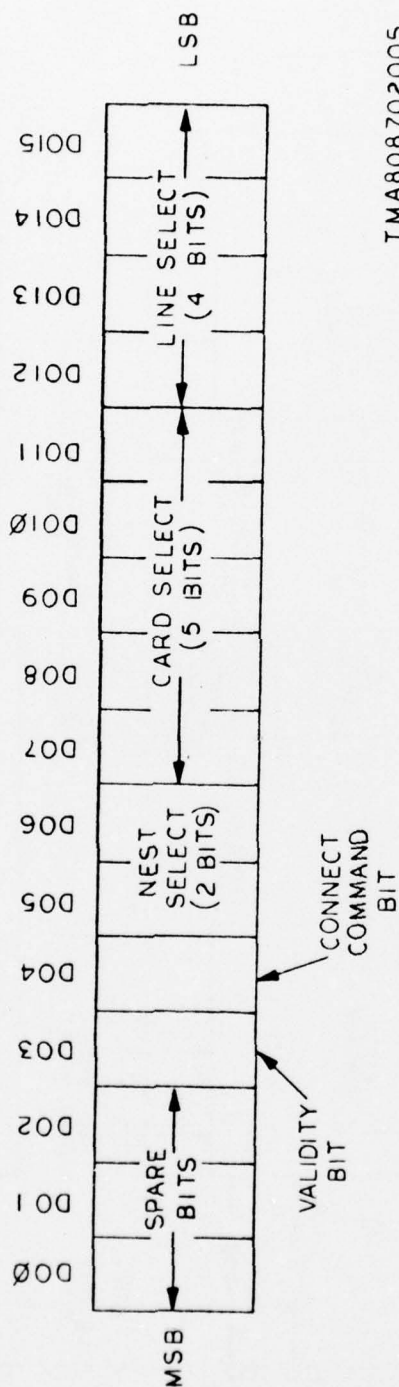
2.3.2.1 Line Selection Logic and Matrix Circuits (Fig. 3).

The Computer Assembly furnishes the input test command data word for the line or equipment to be tested and a timing pulse to initiate the selection process. The sixteen bits of the data word are designated D015 through D00. The structure of this data word is shown in Fig. 4. The bit assignments for each function are specified. Note that three of the sixteen bits are unused. When the operator enters the test request, the 16-bit word from the computer is parallel transferred to the Matrix Interface card, followed by an OUT BUSY signal that is applied to the Matrix Control Logic card (Figure 3). The OUT BUSY signal is combined in the control logic with the D03 data bit, which is present when the data address is valid. The logic circuit subsequently generates the register strobe signal that loads the data word into the 16-bit parallel latch, for storage. During the ensuing period, with the data word stored in the latches, the control logic determines the status of the fault detection circuit and releases the relay matrix from any previous selection. If no fault condition is present, a decoder enable signal is generated.



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Figure 3. VF Line Selection Circuits



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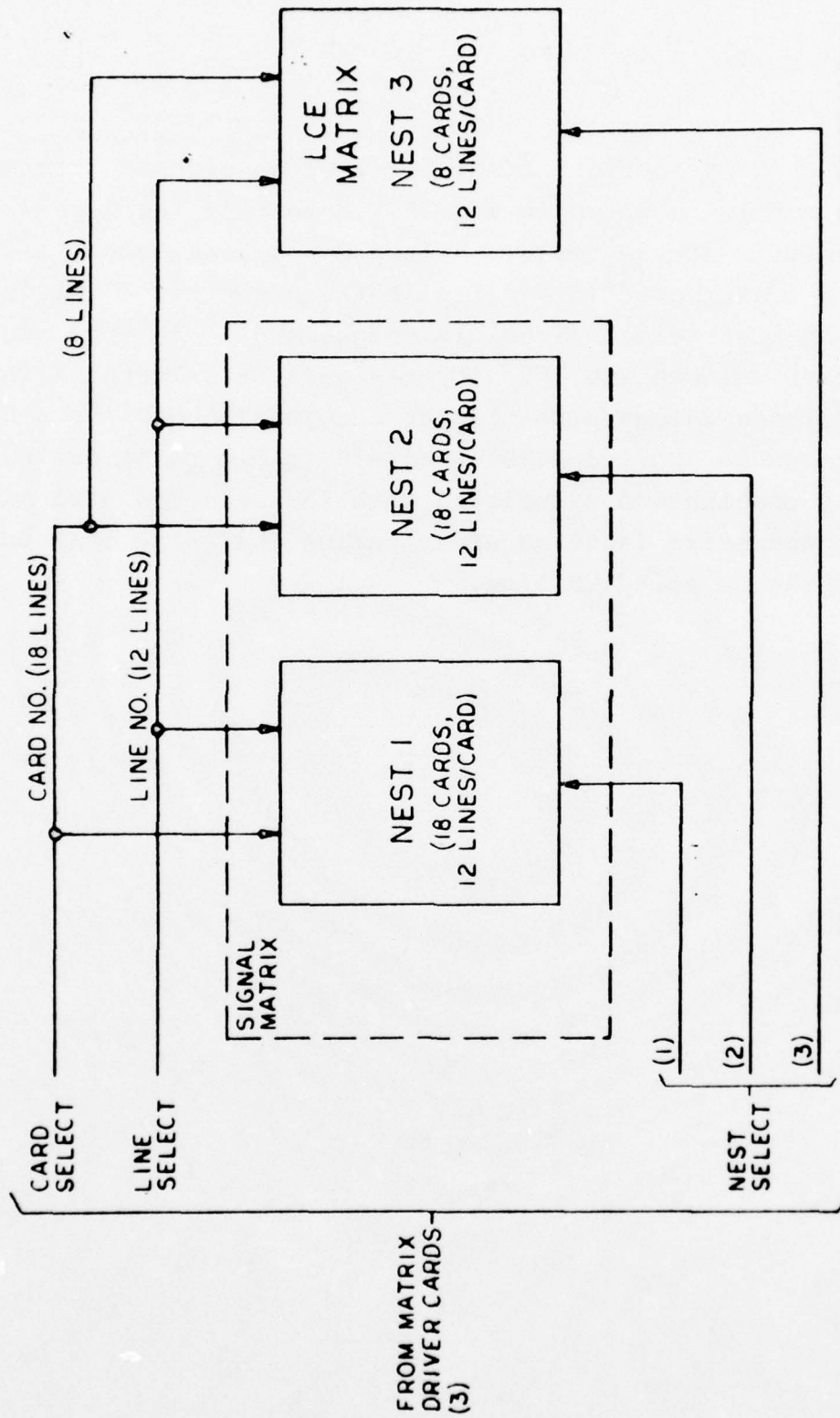
Figure 4. Data Word Bit Structure

The decoder enable signal activates three decoder circuits for line, card, and nest selection. The line decoder is a 1-of 12 decoder, using bits D015 to D012 of the data word for its input. The decoder translates the binary input number (from one to twelve) into an active signal on only one of the twelve output lines. This decimal output signal corresponds to the binary input number. Similarly, the 1-of-18 decoder for Matrix Card selection and the 1-of-3 decoder for matrix nest selection provide discrete single outputs corresponding to the respective input binary numbers. The 1-of-3 decoder circuit generates a lamp driver signal whenever nest number 3, the LCE Matrix, has been selected. This signal lights the LINE COND EQUIP lamp on the Test Select Panel.

The Matrix Driver card stages, of which there is one for each line, card, and nest (comprising a total of 33 separate driver circuits on three PC cards), are primarily current amplifiers designed to operate the relays in the matrixes. Matrix relay operating power is derived from the Matrix Control Logic card and is routed to the selected matrix nest through the associated Matrix Driver card circuit.

The Matrix Control Logic card contains the essential timing, sensing, and control functions for the system. A power-on reset signal applied to the latch circuits provides for automatic resetting of the latches whenever system operating power has been turned off or interrupted. The logic circuits on the Matrix Control Logic card are also reset (internally) by this same power-on reset signal. Output signals are sent to the Test Select Panel to operate the audible alarm and various status indicator lamps. The audible alarm is sounded simultaneously with the lighting of a lamp for the BREAK MODE, FAULT, or NO-CONN conditions. The CONN lamp lights when the system operates normally in selecting a line. The FAULT condition indicates a short-circuit or other cause of excess current flow in the relay matrix. The NO-CONN condition indicates that seizure of the desired VF line was not accomplished due to insufficient current (open circuit) to operate the relay matrix. The BREAK MODE condition occurs whenever any one of certain test function switches on the Test Select Panel is in an up or down position (away from the center-off position) at the time a VF line is being selected. An input to the Matrix Control Logic card (signal OPR LINE BRK) is applied from the Test Select Panel for this break monitoring function. A break condition will prevent acquisition of the desired line until the switches are repositioned.

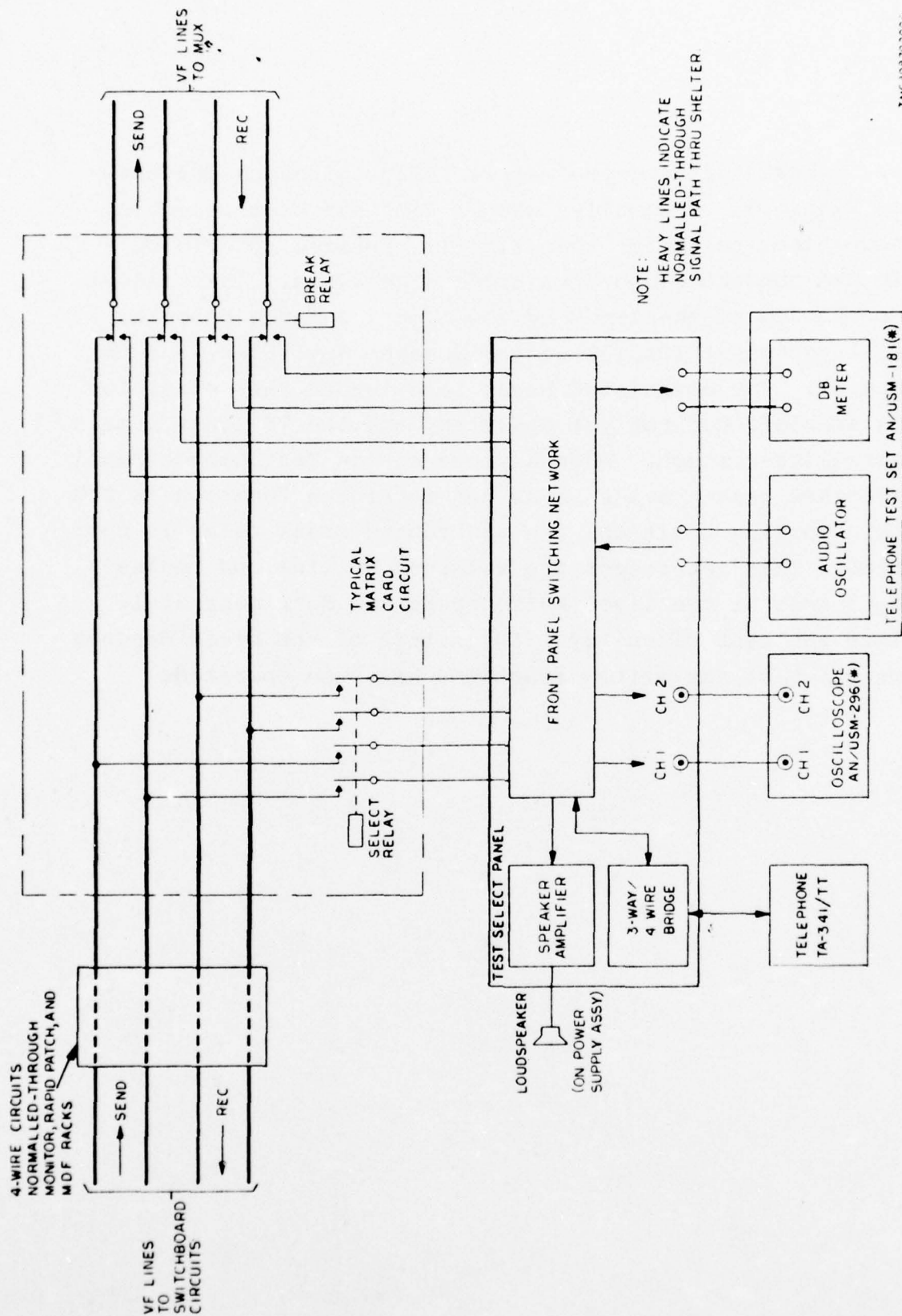
Distribution of relay selection signals from matrix to matrix is shown in Fig. 5. Note that the Signal Matrix consists of two nests. All card and line select signals are distributed in parallel between the three matrix nests. Each nest select signal is unique and it is this signal which defines the circuit that will be selected. That is, even though a particular combination of line and card number is applied simultaneously to all three nests, only the combination associated with the selected nest will be operative in terms of actuating the relay that connects to the selected VF line.



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Figure 5. Distribution Of Nest, Card, And Line Selection Signals

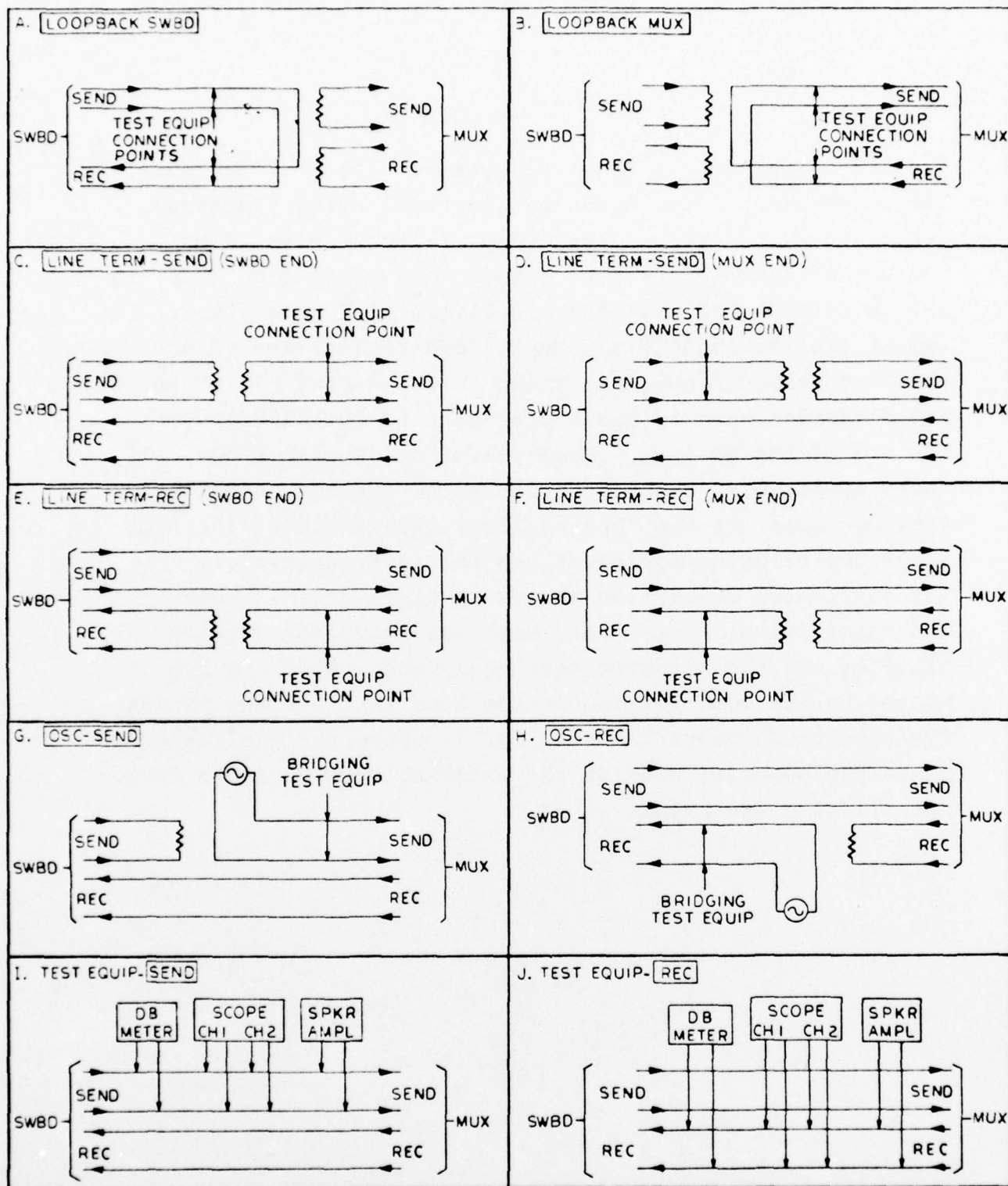
Essentials of the matrix relay switching are shown in Figure 6. Initially, when a line has been selected, the select relay for that line is operated, providing a form-A contact closure to bridge the lines. This allows monitoring of the lines by the high-impedance bridging test equipment (Oscilloscope, Speaker Amplifier, and DB Meter). The associated break relay under this condition is enabled, but not yet operated, and the VF lines remain normalled-through. When any one of the Test Select Panel switches that provide break and terminate function is set to a working position, the associated break relay is operated. This interrupts the external VF line and routes both ends of the line (Switchboard and Mux) separately into the test circuitry. The nature of the break depends on which of the switch functions has been operated.



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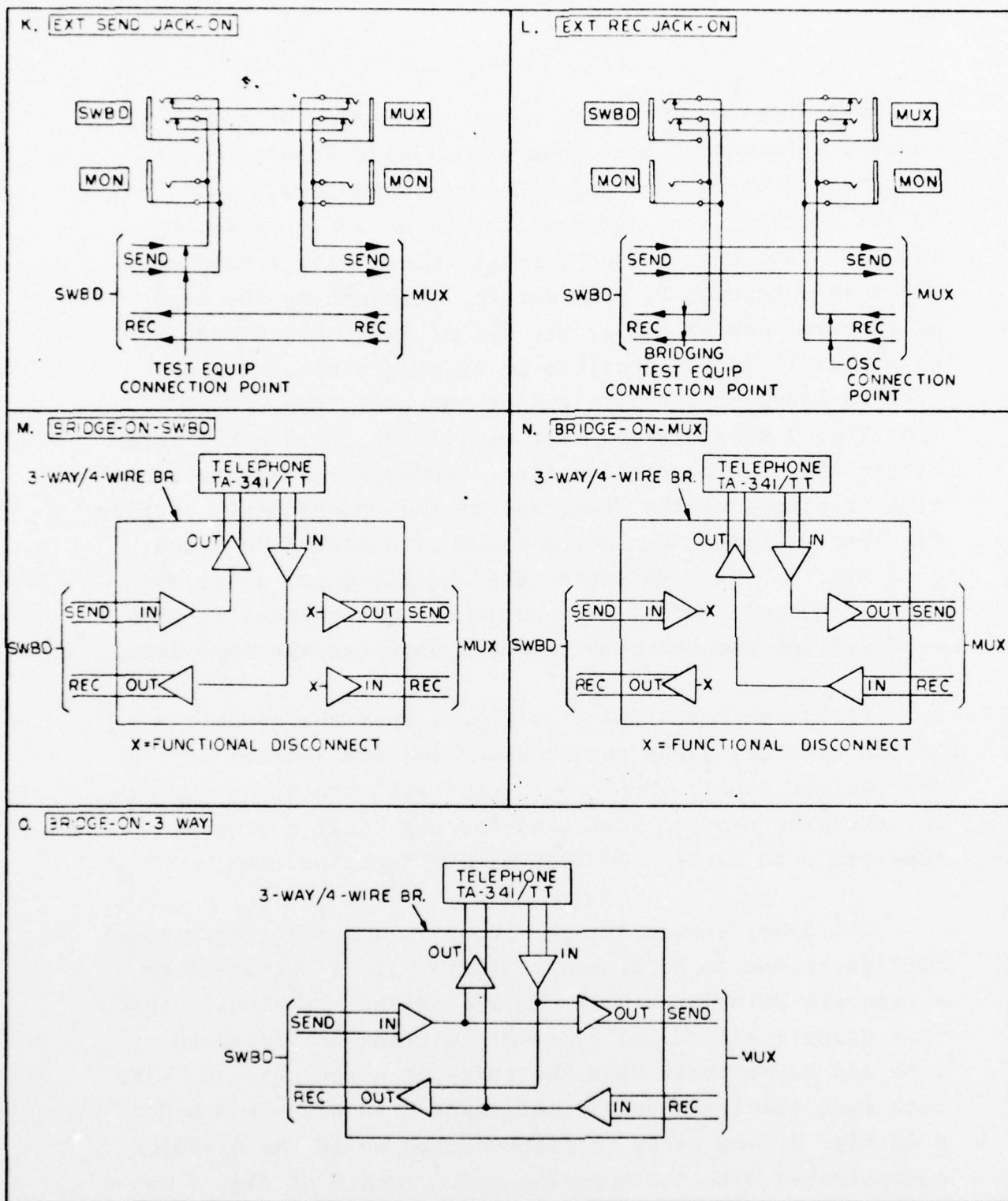
Figure 6. Basic Accessing Scheme For VF Line Monitoring And Testing

2.3.2.2 Test Select Panel Switching. Fig. 7 illustrates the essentials of the bridging and terminating functions performed by the Test Select Panel switches, including the use of the 3-Way/4-Wire Bridge. Each position of every switch (except OFF position) is illustrated separately. Two of the switches (LINE TERM), identically labeled on the Test Select Panel, are shown in C and D of Fig. 7 and are differentiated by their proximity to the SWBD end or MUX end of the VF line. Each illustration also shows, where applicable, the connection point for the associated test equipment to the "break" line; this includes the high-impedance bridging equipment and the test oscillator. The oscillator connection always involves a line break and termination. Note that, with one exception, the oscillator and the bridging test equipment are always connected to the same portion of the line that has the "break." The exception occurs in L of Fig. 7, where the oscillator is at the opposite side of the external receive jacks from the bridging equipment.



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Figure 7. Bridging And Terminating Functions Of
Test Select Panel Switches
(Sheet 1 of 2)



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Figure 7. Bridging And Terminating Functions Of Test
Select Panel Switches
(Sheet 2 of 2)

The loopback function, shown in A and B of Fig. 7 enables terminating both send and receive lines at the Switchboard or Mux end and connecting the send signal back to the receive line. Separate switches are provided to loopback each end, Switchboard and Mux. Line termination, shown in C through F, provides for terminating the send or receive line at either the Mux or Switchboard ends. Note that it is not possible to terminate both send and receive lines at the same end at the same time. G and H of Fig. 7 show how the test oscillator is inserted into either the send or receive line. In both cases a termination is placed at the other end of the opened line. Bridging test equipment connections are illustrated in I and J of Fig. 7. When selecting the oscilloscope, it is possible to simultaneously connect one input channel to the receive line and the other input channel to the send line.

Illustrations K and L of Fig. 7 show the circuit of the external jacks for send and receive located on the Test Select Panel. Note that, even with the jacks switched in, the line remains normalled-through until a plug is inserted into either the SWBD or MUX jack, or both.

The 3-Way/4-Wire Bridge, shown in its three functional configurations in M, N, and O of Fig. 7, is contained on a separate circuit card in the Test Select Panel card nest. This circuit allows the operator to break any selected line and communicate with the party at either end, or with both ends simultaneously (conference bridge). In M and N of Fig. 7, one party is disconnected while the operator communicates with the opposite end. Part O of Fig. 7 shows interconnections between all three parties when the bridge is used in the 3-Way mode.

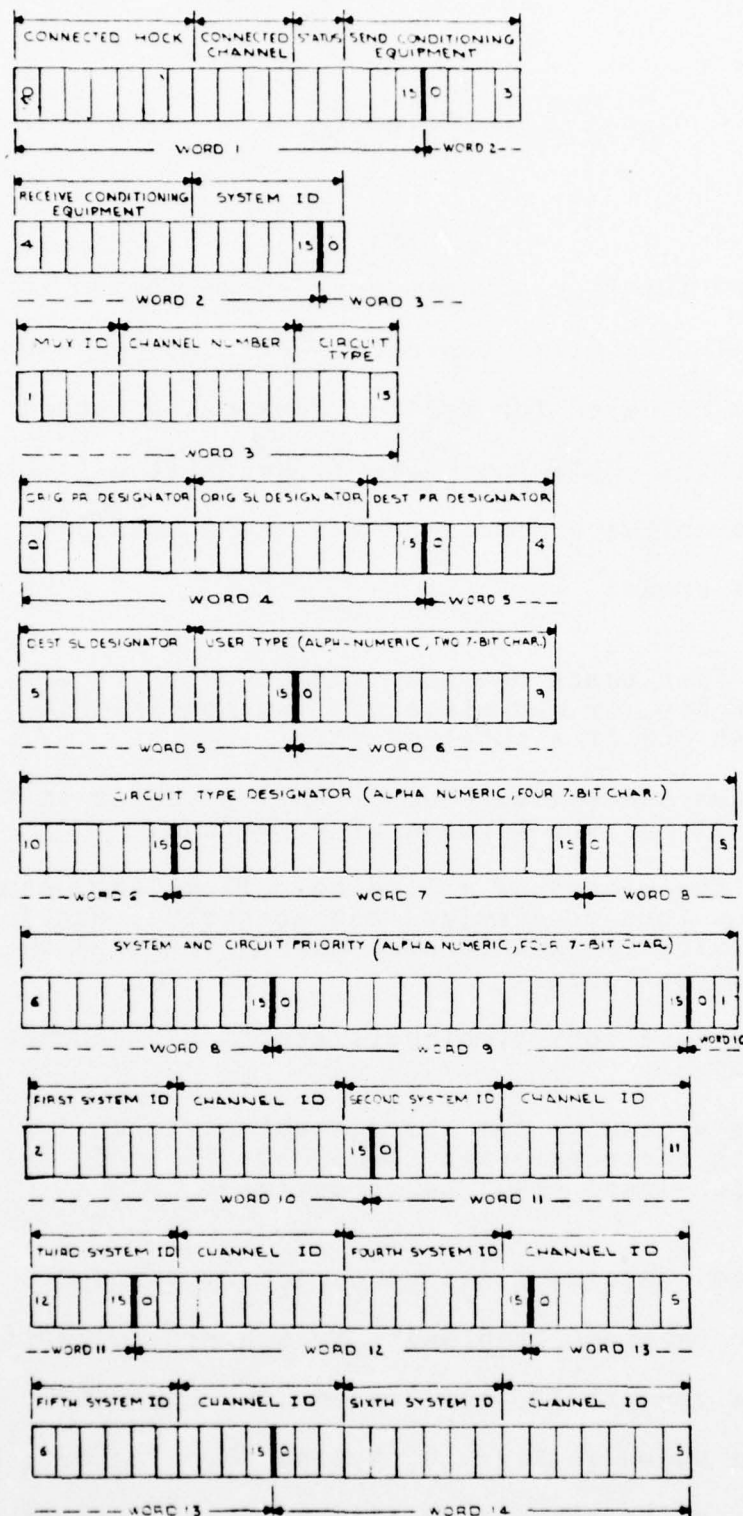
SECTION III SOFTWARE DESCRIPTION

3.1 GENERAL

The primary function of the Upgrade Components is to improve Technical Controller (operator) efficiency by reducing the time required for the performance of record keeping and testing. This improvement, as related to the computer and the software requirements, are specifically in the following areas:

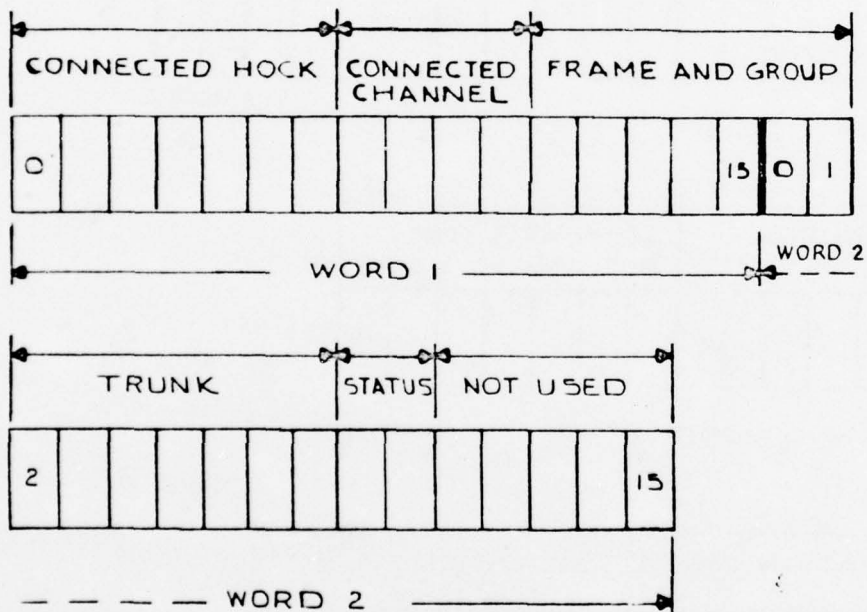
- a. Selects (for test) one specific circuit out of a total of 864, or one piece of line conditioning equipment out of a total of 96.
- b. Identifies unassigned (substitute) channels in the AN/TSQ-84A for the purpose of rerouting.
- c. Updates the record of a line to reflect any changes in status (out-of-service, not connected, etc.) or connectivity (normal-through circuit changed by a patch connection).
- d. Provides hard copy of circuit status and connectivity as needed.
- e. Provides access to the stored tables via an I/O interface with three external low-speed (75 baud) and three high-speed (2400 baud) devices.

The system contains a stored directory divided into three major sections (tables): Switch side circuit ID, Multiplexer side circuit ID, and System ID. Word structure of each table is shown in Figs. 8, 9, and 10. The data stored in these tables can be changed or displayed upon operator requests. Other operator requests enable certain data to be extracted to display specific types of information which can only be obtained by scanning all items in the table.



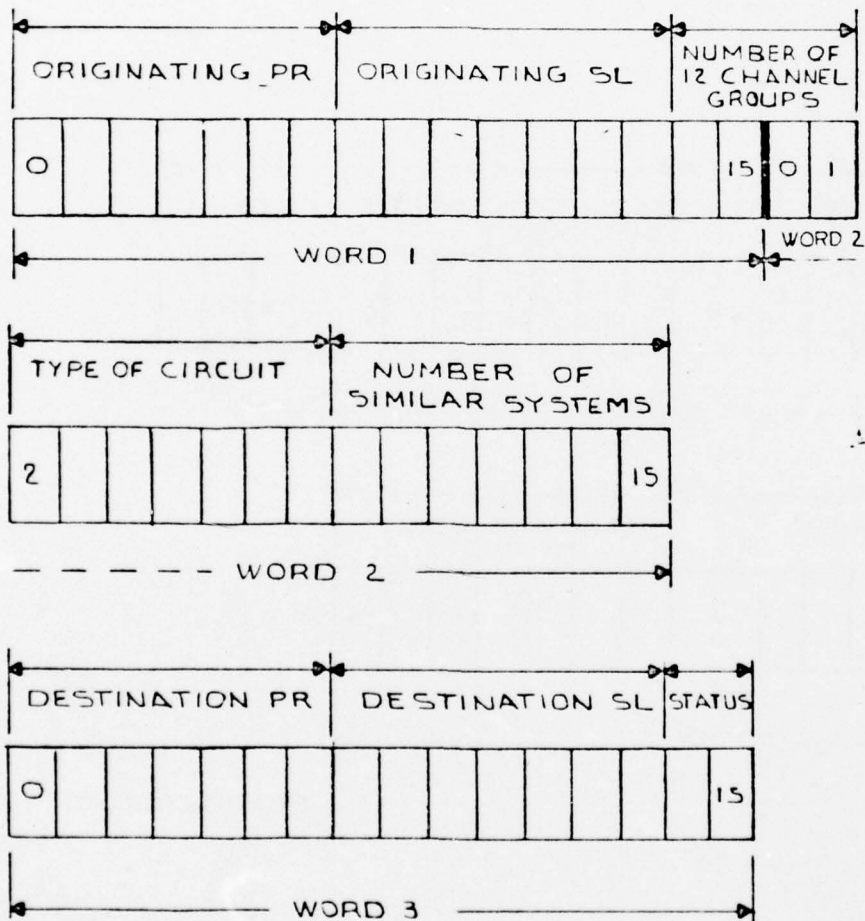
TMC808702009

Figure 8. Multiplex Directory Table 14 Word Entry Format



TMA808702010

Figure 9. Switch Directory Table Two Word Entry Format



TMA808702011

Figure 10. System Directory Table Three Word Entry Format

Except for selecting a specific circuit or line conditioning equipment for test, any operator command which can be entered locally via the ASR-33 or CRT Terminal can also be made from anyone of three remote high-speed (2400 baud) or three low-speed (75 baud) I/O devices. Additionally, a TTC-38 out-of-service input line (75 baud) is interfaced and processed.

3.2 RECORD KEEPING

3.2.1 Access

The operator is able to change any or all the data associated with a circuit or system (directory changes) and is able to display all circuits with some selected particular characteristics (data requests).

3.2.1.1 Directory Changes. Whenever directory changes are in process at any I/O port, reports, directory changes from other ports, and data requests will be inhibited. All directory changes fall in two classes: changes to a line or changes to a system.

- a. Line changes. The operator enters a Hook and Line number and then in an interactive conversational mode the operator enters/changes the data as necessary in either the multiplex or switch ID tables.
- b. Systems changes. The operator enters the abbreviated system ID and then in an interactive conversational mode the operator enters/changes the data as necessary.

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3.2.1.2 Data Requests. Any I/O port may make a data request. The requests can be made in several ways depending on what information is desired. Printouts of the requested information are obtained by requesting any of the following:

a. Single item displays.

- (1) Line data. The operator enters a Hock and Line number and the computer responds with all the information (Circuit ID) for that line.
- (2) TTC-38. Entering a particular TTC-38 frame and line number results in a printout of the circuit ID for that line.
- (3) Conditioning equipment. The operator enters the number of the piece of conditioning equipment and the computer responds with the circuit ID for the line if the equipment is in use or a "NOT FOUND" message if the equipment is not in use.
- (4) System ID cross reference. The operator enters the full system ID and the computer responds with the abbreviated ID, or the operator enters the abbreviated ID and the system responds with the full ID data.

b. Multiple item displays.

- (1) Multiplexer users. The operator enters the code for a particular multiplexer and the computer responds with circuit ID's for all circuits through that multiplexer.
- (2) System users. The operator enters a system abbreviation and the computer responds with circuit ID's for all circuits using that system.

- (3) Out-of-service. The operator may request a list of all out-of-service lines and the computer will respond with the circuit ID's for all such lines.
- (4) Available lines. The operator may request a list of all lines to a particular system that are spare or alternates and the computer will respond with the circuits ID's for all such lines.

3.2.2 Stored Data

The system provides storage for multiplex-side circuit identifiers, switch-side circuit identifiers, and system identifiers. The following are the minimal requirements for each.

3.2.2.1 Switch-Side Circuit Identifier. For each of the 432 circuits that are connected to the TTC-38 switch, the following information is stored:

AABBCDDEFGGH

Where the letters have the following meanings:

- AA - Hock number on the switchboard side (01 thru 36).
- BB - Channel number on the switchboard side (1 thru 12).
- CC - Hock to which the line is patched to. It may be on the multiplex side or possibly looped back to the switchboard (01 thru 72).
- DD - Channel number within the hock above (01 thru 12).
- E - Frame number in the TTC-38 switch that the particular line is coming from (0 - 9).
- F - Group in the TTC-38 switch in the frame above (0 - 9).
- GG - Line in the TTC-38 switch in the frame and group above (01-99).
- H - Represents the status of the circuit. This may be in service, out of service, not connected, etc. (0 thru 3).

3.2.2.2 Multiplexer-Side Circuit Identification.

For each of the 432 circuits that leave the AN/TSQ-84 going towards the multiplex and radio equipment, the following information is stored:

AABBCCDDEEFFGGHHIIJKLLMMNNOPPQQQRRRRSSCCSSCCSSCCSSCCSSCC

Where the above letters have the following meaning:

- AA - Hock number going out to the multiplex side of the shelter (hocks 37 thru 72).
- BB - Channel within that particular hock (channel 1 thru 12).
- CC - Hock number that particular line on the multiplex side is connected to. This may be a line going to the switchboard or it may be looped back to the multiplex side so the hock numbers may be between (1 and 72).
- DD - Channel number associated with hock CC above (channel 1 thru 12).
- EE - Two digit number that represents a piece of line conditioning equipment connected to SEND (toward MUX) side, if one is used. This allows space or up to 96 unique pieces of line conditioning equipment (00 thru 96).
- FF - Same as EE above except for equipment on the RECEIVE side.
- G - Represents the status of a particular line. This may be in service, out of service, not connected, etc. (0 thru 3).
- HH - Two digit abbreviated system identifier that represents a particular system, allowing space for up to fifty different possible systems. Each abbreviated system identifier will have its own full 11-digit system identifier (par. 3.2.2.3). However, in this table only the abbreviated system identifier is needed to act as a pointer that will indicate to the operator which system he has (01 thru 50).
- II - The multiplexer within the system being used by this particular line (00-15).

- JJ - Two digit number represents the channel number that is being used within the system for this particular line (01 thru 99).
- K - First part of the circuit identifier. It designates the type of circuit. There are nine possible circuit types (1 thru 9) where each number represents a circuit type.
- LL - Originating PR designator (00 thru 99).
- MM - Originating circuit SL designator (00 thru 99).
- NN - Destination circuit PR designator (00 thru 99).
- OO - Destination SL designator (00 thru 99).
- PP - Last two digits of circuit identifier that designates the type of use that the circuit is being put to. The type of code depends upon whether it is a sole user, a common user, a special category, etc. (2 alpha numeric characters).
- QQQQ- Circuit type designator from the control routing chart that designates the type of circuit (4 alpha numeric characters).
- RRRR- Priority assigned to the particular circuit that tells the AN/TSQ-84 operator its relative importance with respect to restoration priority, etc. (4 alpha numeric characters).
- SSCC- Group of six two-digit system identifiers (01 - 50) followed by two digit channel identifiers (01 - 99) is a list of the system routing information for that particular circuit. There is adequate area for storing routing for up to six discontinuities between the originator and its final destination. As the circuit is routed through more than one area on its way to the final destination, this system routing chart records each system that it goes through and what channel it goes through in that particular system.

3.2.2.3 System Identifier. For each of the fifty systems abbreviated as a two digit code in the multiplex ID table, the following actual system identification is stored for reference by the operator as necessary.

AABBCCDEFGGHHI

Where the above letters have the following meanings:

- AA - The particular abbreviation that represents the rest of the identifier (01 - 50).
- BB - PR designator for the originating system (00 - 99).
- CC - SL designator for the originating system (00 - 99).
- D - Single alphabetic character designates the type of carrier employed within this particular system. (One alpha character).
- E - The number of 12 channel groups within this one particular carrier (0 - 9).
- F - If there are two systems with the same characteristics, this single alphabetic character is used to differentiate between the two systems (one alpha character).
- GG - PR designator for the destination of the system (00 - 99).
- HH - SL designator for the destination of the system (00 - 99).
- I - Single digit representing the operational status of the particular system. This may be in service, out of service, discontinued, etc. (0 - 3).

3.3 TESTING

Testing of circuits and line conditioning equipment will be under program control to the extent that the operator must enter a predetermined code and then designate a hock and channel number (or line conditioning equipment number). In response, the computer will output a 16-bit command word to a matrix control circuit where the word will be decoded to select a specific matrix relay corresponding to the selected circuit. The circuit will then be automatically seized via the energized

matrix relay and two high impedance bridged appearances (send and receive paths) will be presented to the operator.

3.4 PROGRAM FUNCTIONS

Processing and control is performed by the computer program and is capable of performing the following tasks:

- a. ROLM supplied control program controls the device handling, scheduling, and initialization.
- b. STELMA supplied operational program controls the program tasks (one for each operator command) to determine what processing must be accomplished, and then perform that required processing.

3.5 GENERAL PROGRAM INFORMATION

The processing requirements of the AN/TSQ-84 upgraded system are handled by a real-time core resident computer program called 84CP, written in assembler language for the ROLM 1602 computer. The 84CP performs the following tasks:

- a. Initialize all devices and tables necessary before processing operator requests.
- b. Analyze the operator request for validity and set up task parameters needed.
- c. Process the three types of requests called Display, Change, and Test.

3.5.1 Input/Output Channels

In the AN/TSQ-84 Upgrade configuration, the 84CP provides for the following inputs/outputs:

- a. Inputs/outputs from three baudot multiplexer lines at 75 baud.

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- b. Inputs from one baudot multiplexer line at 75 baud carrying TTC-38 out-of-service messages, as well as other messages that the 84CP will disregard.
- c. Inputs/outputs from four ASCII multiplexer lines at 2400 baud (including the CRT Terminal in the shelter).
- d. Inputs/outputs from the ASR-33 ASCII teletypewriter (110 baud).
- e. Output to associated matrix control assembly.

3.5.2 Task Scheduling Method

The 84CP task scheduling and input/output control are made through the task and system commands of RTOS (real time operating system supplied by ROLM). This is to facilitate system change by the procuring agency and allow rapid modification for future addition of computer-to-computer information interchange.

3.5.3 Program Source Language

The 84CP is written in assembler language for the Rolm 1602 ruggedized minicomputer.

The 84CP is assembled off-line using the:

- a. Assembler
- b. Relocating link loader
- c. Conversational debug program
- d. RTOS System Generation (SYSGEN) Programs.

3.5.4 Core Memory Requirements

The 84CP^e operates in a core memory containing a minimum of 16,384 words (16-bits per word). The memory contains needed RTOS routines, the record keeping and test routines, and the required table areas.

3.6 GENERAL PROGRAM TASKS

The functions of the 84CP are performed by the following three types of tasks:

- a. The initialization task opens all I/O devices and sets up individual operator requests demanding tasks.
- b. The operator request demanding tasks prompts each terminal port, then receives and verifies operator requests.
- c. The command tasks perform the operator requests demanded.

3.6.1 The Initialization Task

3.6.1.1 Input. The initialization task is the first task processed by RTOS upon system start-up. The starting address of this routine is established during the RTOS SYSGEN routine.

3.6.1.2 Processing. The initialization opens all devices (TTY input, TTY out/put, and the 8 multiplexer lines) using RTOS system commands. All input/output buffer areas are set to zero. An operator request demanding task is set up for each active input device (TTY input, 6 multiplexer lines) using RTOS task commands. (Two multiplexer lines allocated for computer-to-computer I/O are not processed any further since no task has been defined by the procuring agency at this time.)

3.6.2 Operator Request Task

3.6.2.1 Input. One of the 15 possible operator requests transmitted in ASCII or Baudot code can be sent by each input device to the computer. The possible codes are as follows:

<u>Code</u>	<u>Desired Action</u>
o DD (C/R)	Display Date and time
o DO (C/R)	Display all out-of-service lines
o DL (C/R)	Display line by hook & line number
o DB (C/R)	Display switchboard TTC-38 number
o DC (C/R)	Display user of a piece of line conditioning equipment
o DI (C/R)	Display the full system identifier corresponding to abbreviated system identifier
o DA (C/R)	Display the abbreviated system identifier corresponding to a full system identifier
o DM (C/R)	Display all users of a particular multiplexer
o DS (C/R)	Display all users of a particular system
o DN (C/R)	Display all lines in use on a particular system
o CL (C/R)	Change a line of a circuit identifier
o CS (C/R)	Change a system identifier
o CD (C/R)	Change data & time
o TL (C/R)	Test line
o TC (C/R)	Test conditioning equipment

NOTE

Only the ASR-33 Teletypewriter and the CRT terminal in the AN/TSQ-84 shelter are allowed to use the two test requests, TL and TC.

3.6.2.2 Processing. A task is set up for each input device. A (C/R) and (L/F), followed by a colon are sent to the input device to indicate the I/O device is ready for input. When the operator types a command, it is read in, echoed, and stored in an input buffer on a character by character basis until either a carriage return terminates the input stream or until seventy two legal printable characters have been processed. If the input device produces baudot code, the input stream is converted to ASCII code. The input stream is then compared to a table of allowable operator requests. If no match is found between the input stream and possible operator requests, an INVALID REQUEST message is sent in the device's characteristic language and a new command input sequence is started. If a command has been analyzed and found correct, a task is set up to process the operators request.

3.6.2.3 Output. If the input command stream does not match any one of the possible operator requests or the request entered is not allowed for the calling device, an "illegal request" type of message is sent to the requesting device.

3.6.3 TTC-38 Outage Reports

3.6.3.1 Inputs. The TTC-38 printer channel supplies the AN/TSQ-84 shelter with a stream of messages. Every message is checked for the following message format in Baudot code:

(c/r)(l/f)a-b-cc(s/p)dd(s/p)(s/p)eee (s/p)LK(s/p)LK(s/p)OUT(c/r)

where the above codes have the following meanings:

<u>Code</u>	<u>Meaning</u>
-	Dash to separate numbers
a	Frame number
b	Group number
cc	Trunk Number
dd	Type of trunk
eee	Trunk group number
LK (s/p) OUT	Lock out indication
(c/r)	Carriage return
(l/f)	Line feed
(s/p)	Space

3.6.3.2 Processing. A line of data is read in, echoed, and stored in an input data buffer, character by character, until either a carriage return terminates the input stream or until seventy-two legal printable characters have been processed. The line of data is then checked for the pattern "OUT" occurring after the 18th printable input character. If this pattern is not recognized, the data line is disregarded and the processing of a new data line restarted.

3.6.3.3 Output. Once the out-of-service message is recognized, an abbreviated message of the following form is printed on the ASR-33:

(Bell)(c/r)(Bell)(l/f)(l/f)abcc(s/p)OUT(c/r)(l/f)(Bell)(l/f)(Bell)

where the above codes have the following meanings:

<u>Code</u>	<u>Meaning</u>
a	Frame
b	Group
cc	Trunk number
(c/r)	Carriage Return
(l/f)	Line feed
(s/p)	Space
(Bell)	Bell character (rings bell in TTY)

The TTC-38 out-of-service message will disrupt normal ASR-33 messages. Since the input data rate is slightly faster than the ASR-33 printing rate, non-pertinent characters are deleted from the message; consequently the printing function is faster than the input so that buffers are not required to store succeeding messages.

3.7 DESCRIPTION OF MAJOR PROGRAM TASKS

3.7.1 Start-Up of Program

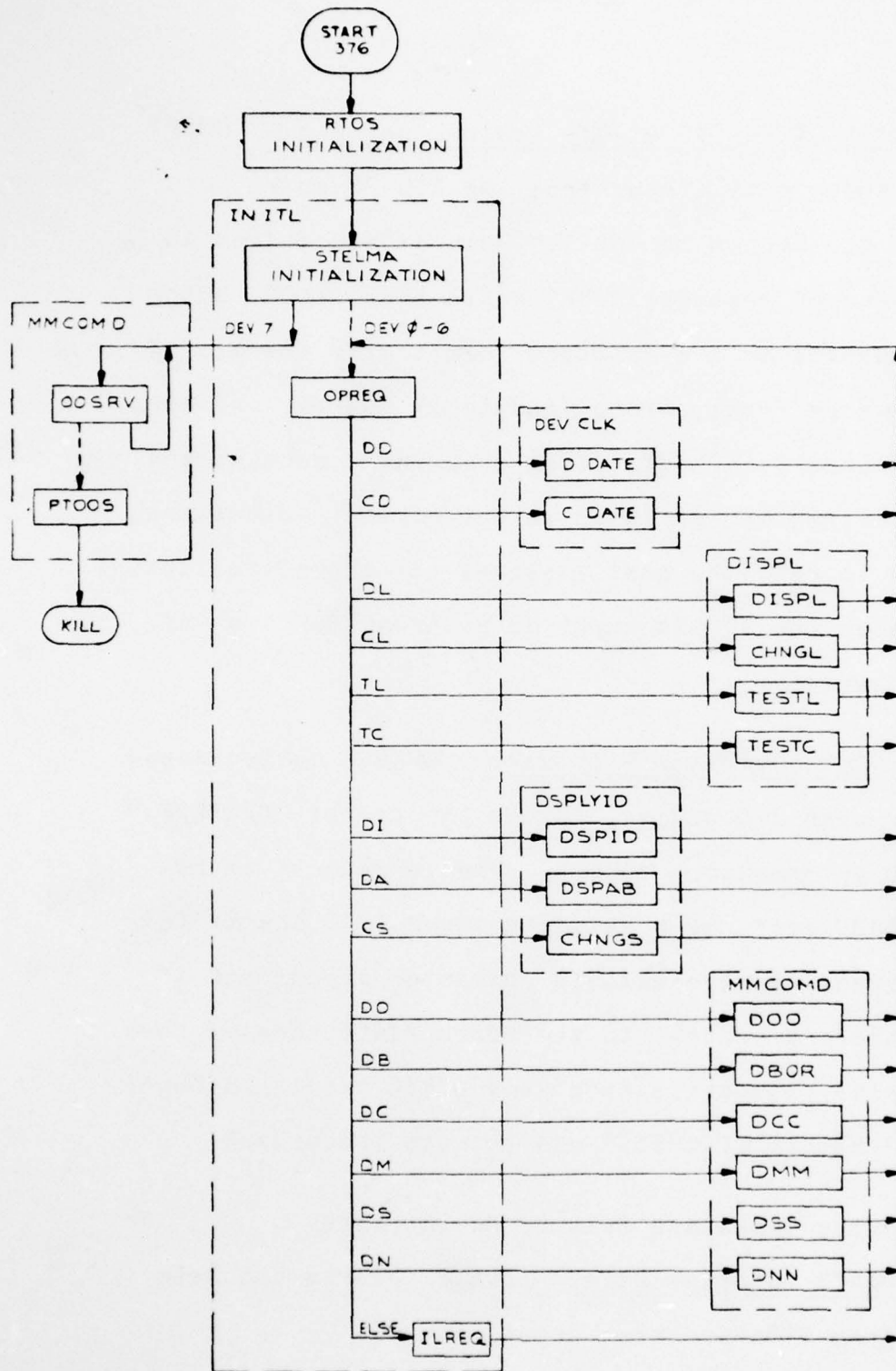
3.7.1.1 Starting Address. When the system program is started at location 000376, control is transferred to the ROLM supplied Real Time Operating System (RTOS). RTOS then initializes its tables and flags and prints an identifying message; "ROLM RTOS REV 3.02." It then enables interrupts and jumps to STELMA initialization program INITL.

Fig. 11 is a general flow chart which gives an overview of system program flow.

3.7.1.2 INITL (Initialize). INITL performs the following tasks:

- o clears the STELMA flags,
- o clears the device save areas,
- o writes the appropriate device numbers in the first word of each save area,
- o opens all the I/O channels.

INITL then creates the operator request task OPREQ for each I/O device except the TTC-38, and jumps to the out of service task OOSRV.



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Figure 11. General System Flow Chart

3.7.1.3 OOSRV (TTC-38 Out-of-Service Request). OOSRV inputs a baudot data stream from the TTC-38 and translates the stream to ASCII. When it recognizes an "out of service" message, OOSRV calls task PTOOS, which prints a message on the teletype identifying the out of service line by frame, group, and trunk number, and then terminates itself. OOSRV, after checking a message and deciding whether or not it is an out of service message, loops back to read the next message. It therefore continuously checks the TTC-38 input data stream for "out of service" messages.

3.7.1.3 OPREQ (Operator Request). OPREQ, called separately for each I/O device, issues the prompt "C/R L/F:" and inputs an operator request. When a request is received, OPREQ performs a validity check. It checks for validity based on recognizable character groups and if valid, transfers control to the appropriate service task. If an invalid request is received, OPREQ prints an error message, "INVALID REQUEST," and repeats the prompt.

3.7.2 Service Tasks and Related Subroutines

3.7.2.1 DDATE (Display Date). DDATE fetches the date and time from RTOS and then prints them.

3.7.2.2 CDATE (Change Date). CDATE fetches and prints the date and time. CDATE then inputs a new date and time from the operator, converts it to ASCII if from a Baudot device, and then checks for validity. If the day and month are valid, the system clock is changed to the value inputted. If the month is greater than 12, the day greater than 31, or if an error return is taken, CDATE prints the error message, "INVALID RESPONSE."

3.7.2.3 DISPL (Display Line). DISPL prints "HHCC:", inputs the operator response, and checks the response for validity. An invalid hock or channel number causes an error message. If the hock and channel are correct, DISPL prints the appropriate heading. Control is then transferred to OPREQ to ask for the next request.

3.7.2.4 CHNGL (Change Line). CHNGL uses the same coding as DISPL up to and including printing the data. It then inputs modifications to the data, and merges the modifications with the data. The resulting originating (first) hock and channel are checked for validity. If either is invalid, an error message is printed. If both are valid,

check validity of terminating (second) hock and channel; an error message is printed if the second hock or channel are invalid. If both hocks and channels are valid, check validity of the remaining data. Invalid data results in an error message telling the operator which entry was out of limits. After the data has been found valid, it is repeated to the operator for verification, in ASCII or Baudot (as appropriate depending on the I/O device used).

If the operator changed the destination hock or channel, CHNGL checks for a previous connection to the new hock and channel, and prints a message to alert the operator to the previous connection, if any. CHNGL then asks the operator if he wants to make the change. If not, returns control to OPREQ for the next request.

CHNGL updates the table entry with the new data. CHNGL then checks to see if the destination hock or channel was changed. If there is a new destination, the previous connection to the new destination is checked to see if it was normal-through. If it was, the connection to the normal-through line is cleared in the table.

If the new destination hock and channel are entered as zero (indicating a terminated line) the normal-through from the originating line is checked to see if it was patched to another line (indicating that the line being changed was patched to a different line) which now is being opened. If not patched, the connection was normal-through and the connection is changed to open in the table.

If the destination-open designation is removed, the normal-through from the old destination is checked to see if it is open in the table. If so, both opens are removed and the normal-through connection is re-established on both sides.

After all changes have been made, the program checks to see if the change was made by the ASR-33 in the shelter. If it was, control is returned to OPREQ for the next request. If not, a notification record message is printed on the shelter ASR-33 so that all changes leave a hard-copy record. The message also indicates the I/O device which initiated the change.

3.7.2.5 TESTL (Test Line). TESTL checks that the requesting I/O device is in the shelter (ASR-33 or CRT) and prints an illegal request message if requested from outside the shelter. If the request is from inside the shelter, the same logic for DISPL is used to request, input, and check a hock and channel number. An additional

test is made to ensure that the hock number is greater than thirty-six. The hock and channel number are formatted into the command word format and outputted to the test and select card (SPTP). After acknowledgement that the card received the command is received, control is transferred to OPREQ for the next request.

3.7.2.6 TESTC (Test Conditioning Equipment). TESTC checks that the requesting I/O device is in the shelter, then uses subroutine INTRO to request and input the conditioning equipment designation. The operator's response is checked for validity, and if valid is formatted into the command word format, which is then outputted using the same logic as TESTL.

3.7.2.7 DSPID (Display Full System Identification). DSPID requests a system number, then checks the validity of the operator response. An invalid system number prints an "INVALID RESPONSE" message and seeks a new request. If a legal value is entered DSPID fetches and prints the full system identification corresponding to the operator entered abbreviated identification, then seeks a new request.

3.7.2.8 CHNGS (Change Full System Identification). CHNGS uses the same logic as DSPID up to and including printing the full system identifier. CHNGS then

inputs an operator entered update and merges the update with the original data. The updated abbreviated ID is checked for validity of the updated line. If there is an invalid entry in the data, the operator is shown which entry was incorrect. If the changes are valid, the entire updated line is printed for operator confirmation and the operator is asked if he wants to change. If he does, CHNGS enters the updated data in the table.

After making the change, if the requesting I/O device was not the shelter ASR-33, a message announcing the change is sent to the ASR-33 for hard-copy record. Control is then transferred to OPREQ to ask for the next request.

3.7.2.9 DSPAB (Display Abbreviated System Identification).

DSPAB outputs the heading for the system identifier, omitting the abbreviated identifier and status heading, then inputs an operator entered identifier. DSPAB then checks the validity of the entry and if valid converts it to table format. If the entry is not valid, the incorrect entry is indicated to the operator and asks for the next request.

The entry is then compared to each entry in the system ID table, ignoring system status. For each match found, the location in the table (i.e., the abbreviated ID) is outputted to the I/O device. If no match is found, it indicates that no system has the requested identifier. If at least one match is found, control is returned to OPREQ after the complete table is searched.

3.7.2.10 DMM (Display All Users Of A Particular Multiplexer).

DMM requests and inputs a multiplexer specification from the operator. A validity check is performed and if the specification exceeds the limits, the operator is notified and seeks a new request. If the specification is legal, DMM formats it into table format and compares the multiplexer specification to each entry in the multiplex side table. If a match is found, DMM prints the heading and first matching table entry. For each subsequent match, only the table entry is printed. After the entire multiplex side table is searched, control is returned to OPREQ to seek the next request. If no match is found, it informs the operator that multiplexer designation was not found.

3.7.2.11 DOO (Display All Out Of Service Lines). DOO

first searches the multiplex side table, line by line, for out of service lines. If any are found, they are

printed out, preceded by the multiplex side heading. When the entire table has been searched D00 searches the switch side table, line by line, for out of service lines. Any out of service lines are printed out, preceded by the switch side heading. After the entire switch side table is searched D00 searches the system identifier table, system by system, for out of service systems. If any are found, they are printed out, preceded by the system identifier heading. D00 then checks to see if any out of service lines or systems were found. If so, control is returned to OPREQ for the next request. If not, the operator is informed that no out of service entries were found and to seek a new request.

3.7.2.12 DBOR (Display TTC-38 Frame, Group, And Trunk Number). DBOR requests and inputs a frame, group, and trunk number and check it for validity. This number is then arranged in table format, and DBOR searches the switch side table for that combination. Any matches found are printed out, preceded by the switch side heading. If none are found, the operator is informed that that combination of frame, group, and trunk number does not appear in the table. Otherwise, control is returned to OPREQ to seek the next request.

3.7.2.13 DCC (Display User Of A Particular Line Conditioning Equipment). DCC requests and inputs a conditioning equipment designation and check it for validity. The operator is notified if the designation was invalid. If the

designation is valid, the multiplex side table is searched line by line for that piece of conditioning equipment on the send (multiplex) and receive (switch) side.

If a match is found in either position, the line is printed out, preceded by the multiplex side heading.

The next line is then checked as above, until the entire table has been searched. If no match is found in the table the operator is notified that that piece of conditioning equipment was not found and return control to OPREQ.

3.7.2.14 DSS (Display All Users Of A Particular System).

DSS requests and inputs an abbreviated system ID.

A validity check is performed and if the operator entered ID is invalid, the operator is notified. If the ID is valid, each line of the multiplex side table is checked to see if any of the seven systems entered in that line matches the operator entry. If so, that line is printed preceded by the multiplex side heading if necessary.

DSS then checks the next line as above until the whole table has been searched. If no match was found, the operator is notified that that system was not found. Otherwise control is returned to OPREQ to get the next request.

3.7.2.15 DNN (Display All Lines Not In Use In A Particular System). DNN uses the same logic as DSS except that when a match is found the line status is checked for available status. If not available, the line is treated as no match.

SECTION IV
ENVIRONMENTAL TESTING

4.1 GENERAL

In accordance with the contract, the AN/TSQ-84 Upgrade Components were subjected to various engineering evaluation tests. The following paragraphs summarize the results of these tests.

4.2 ELECTRICAL AND SOFTWARE PERFORMANCE

The system was subjected to the tests of EDTP Attachment 1 and the performance was within the requirements.

4.3 HIGH TEMPERATURE, LOW TEMPERATURE, AND HUMIDITY

The system was exposed to high temperature, low temperature, and high humidity environments per EDTP Attachment 2A with no adverse effects. Performance was completely normal when at the following extreme conditions:

Temperature - Operating: -25°F to +125°F

Temperature - Non-operating: -70°F to +160°F

Humidity range - Up to 98% including condensation
due to temperature changes.

4.4 RELIABILITY AND MAINTAINABILITY

The system was subjected to a Reliability Test per MTP-0315/3-376. This test verified a MTBF of at least 300 hours. The system was also subjected to a maintainability demonstration per MTP-0315/2-675. The test demonstrated a MTTR of 20 minutes.

4.5 MECHANICAL

The system's mechanical requirements were verified per EDTP Attachment 7. All the requirements were within tolerance.

4.6 EMI

The Computer, the Power Supply, the Test Select Unit, the Matrix and the CRT Terminal were each subjected to EMI tests per EMITP-TSQ-84/3-126. The Computer, the Power Supply, the Test Select Unit and the Matrix all met the requirements of the MIL-STD-461 specifications.

The CRT Terminal did not meet all the requirements of MIL-STD-461, however, the test was conducted for information only (requested by procuring actively). The CRT Terminal is a commercial device and it was expected that the test would show that the unit would not meet MIL-STD-461.

4.7 ELECTRICAL/MECHANICAL

Each of the individual units were tested per EDTP Attachments 3, 4, 5 and 6. Each unit successfully passed the test.

4.8 VIBRATION, SHOCK, AND BENCH TESTS

The Power Supply, the Test Select Unit, and the Matrix were subjected to the tests of EDTP, Attachment 2B. The items all performed satisfactorily.

SECTION V

RECOMMENDATIONS AND CONCLUSIONS

5.1 GENERAL

This section describes various recommendations for enhancements to the TSQ-84A that are worth consideration now as well as in the future. The enhancements are of a nature that they could be added in the future either prior to production or even after production as a retrofit for field units. The conclusions presented are a general summary describing the observations that were made during the course of the design, and explain the nature of the rationale for the various design decisions that were made with respect to the delivered system.

5.2 RECOMMENDATIONS

The following paragraphs briefly describe four general areas of recommendation for enhancements to the existing system, to add new capabilities, or expand the existing capabilities within the system. The areas discussed are:

- Mass Storage
- Report Generation
- High Speed Reload
- Cable/Loopback Test

5.2.1 MASS STORAGE

The existing system uses the core memory in the ROLM 1602 Computer as its storage device for not only the programs required to operate the computer, but also for the directory tables that contain the routing information and the connectivity data for all the circuits going through the TSQ-84. The 16K core memory is presently utilized; with about 8K dedicated to the table storage areas, and the remaining 8K used to store the computer programs. The tables are themselves designed to be as compact as possible in order to fit within the 8K allocated to them. The information selected to be retained in those tables is a subset of the control routing charts normally used by the Technical Controller. During the various discussions that were held

in the design phase, between STELMA and the various participating agencies, it became apparent that it might be desirable in the future to expand the table storage space considerably. The expansion of table storage space would certainly allow for the storage of more data and give the Technical Controller a more powerful tool than he already has.

There are several ways the Mass Storage can be affected. One way is to use the existing expansion space in the ROLM 1602 Computer and add two more 8K core memory stacks, bringing the total memory size to 32K. This represents 100 percent expansion in memory size which is equivalent to a 300 percent expansion in table storage area. This expansion would be the most straight forward since the only requirement would be to simply plug in two more modules. The space is already available in the computer, and the power supplies are capable of supporting the additional two modules. This does, however, have certain limitations as a solution. One of the limitations is in the area of cost since core memory is a rather expensive method for bulk storage. The second limitation is that the flexibility in such an expansion is definitely limited without resorting to considerable new hardware in the form of a *memory management* system which would be required to ever expand beyond 32K. A memory management system requires a page memory which causes problems in programing. For all practical purposes a 32K core memory is the largest practical expansion that could be recommended.

The second technique for mass storage is an external magnetic storage devise, probably a disc. There are several discs available to operate with the ROLM 1602. These discs come in several sizes ranging in the one to five million bite capacity. This type of storage certainly offers a considerable expansion in volume, versus that which could be attained using a core memory. However, the major problem with this approach is in the area of cost.

The cost of any sort of a disc system would be about twice that of a similar core memory expansion. A second problem is that it does add more hardware to the basic system with all of the attendant problems of adding such hardware. As an alternate, a magnetic tape unit could also be considered. However, there are certain problems inherent with magnetic tape units. Although they are cheaper, they do not have the flexibility of application that a disc unit has in that they are not random access units. Secondly and perhaps more importantly they tend to be a maintenance problem in that they are not as reliable as a disc unit due to their inherent design.

The addition of a mass storage device, provides a flexibility in the TSQ-84 considerably above and beyond the existing system. With the additional storage space, it would be possible to implement a whole raft of new improvements. One would be able to eliminate, for instance, the order wire teletype (The Baudot Kleinschmitt Unit) since the disc would give the ability to queue up messages until such time as they could be displayed on the CRT Terminal without disturbing the operator. It would also allow storage of historical record-keeping data about the daily events that have taken place in the shelter which could then later be transferred to paper tapes or transmitted via one of the high-speed ports elsewhere for recording and eventual analysis. The storage also would allow expansion of the existing record-keeping tables to allow for the use of comment columns, etc., that are called out in the TRADOC Operations Handbook. All the various forms and procedures that are called out in that handbook could then easily be implemented since the space would be available to store the basic forms and to store the forms after they are completed by the operator with the aid of the computer.

It should be understood that most of the limitations in the existing system were limitations based solely on the fact that additional storage space was not available at that time. The mass storage would also open the possibility of using the computer in the TSQ-84 for other purposes which presently are envisioned as taking place in different shelters; i.e., some of the functions in the CNCE of the TCCF System, some of the traffic reporting data reduction related to the TTC-38 Switch. From the above partial list one may quite easily see why the mass storage is such a pivotal item in the future expansion of the TSQ-84.

5.2.2 REPORT GENERATION

The reports generated by the existing TSQ-84 Computer System are somewhat limited in scope and do not presently conform to the DCA reporting formats. One of the topics under discussion during the development of the TSQ-84 was the future enhancement of the reporting capabilities that are inherent in the computerized system. This is certainly an area that bears careful attention and would be most fruitful in terms of any expansion.

The computer has the various raw data stored within it to provide the operator with many reports in an automated fashion that he must presently do manually. As the TCCF System evolves, and its report formats are finalized, these report formats should be built into the TSQ-84 so that its automatic reporting capability is functionally with the TCCF System. The report generation capability depends to some extent upon the bulk storage device chosen for use within the system. Obviously, if a mass storage device is employed

in the system, far more data is available in the mass storage device to be used to generate reports. The Mass Storage Device, therefore, can also store the various formats and forms necessary for the operator to generate reports in acceptable DCA format. This also provides the space to store many of these reports for historical purposes and allows the operator to recall them at will.

The whole area of report generation has been purposely treated very lightly in the existing system since the exact requirements would be very difficult to specify until some experience with the system has been obtained.

5.2.3 HIGH SPEED RELOADING

The present system depends for reloading upon the Model ASR33 Paper Tape Reader. Although the reader is quite reliable, it is a relatively cumbersome system since reloading a 16K Memory with the reader requires almost one hour. There are several possible solutions to this problem which are worthy of further investigation. The most straight-forward solution is to provide a high-speed paper tape reader utilizing the existing parallel input/output channel in the ROLM 1602 Computer. As a matter of fact, this is the technique that was used to load the computer during the development phase in the laboratory environment.

A second possible consideration would be to consider using a CRT Terminal with a magnetic tape cassette option built into the terminal. There are several of these machines available today one of which is produced by Hewlett-Packard; the manufacturer of the CRT Terminal that is presently used in the system. This technique would permit high-speed loading, via magnetic tape cassettes, of the programs and/or stored tables as well as allowing a high-speed technique for writing out the tables from the computer core memory to magnetic tape. This is a task that the high-speed Paper Tape Reader is incapable of doing.

With the present system, after the tables are loaded into the system, via the operator's keyboard, a copy of the tables is stored off-line on paper tape. This is done for future reload and/or restoral in case of a malfunction in the computer core memory that would necessitate a memory replacement. The present technique for making this tape is to punch it out using the ASR33, which requires approximately one-half hour. A magnetic tape cassette would enable an operator to perform this function quite rapidly; probably in less than two minutes.

These magnetic tape cassettes could also be used to store diagnostic programs used for computer maintenance to insure that the computer is operating properly. After these tests are performed, the operating program, as well as the operating tables could be reloaded into the computer restoring the computer to full operation capability.

If a mass storage device is added to the system, it becomes even more important to have some technique for rapid loading since a considerable amount of tables may be stored on the mass storage device and reloading with a low-speed Paper Tape Reader would be somewhat impractical. Although there are several other techniques that could be used for high-speed reload, because of cost and/or environmental considerations they are most likely not worth investigating at this time.

5.2.4 CABLE/LOOPBACK TESTER

The upgrade to the TSQ-84 has installed a matrix in all of the signal lines that enter the shelter. This matrix gives the computer and test equipment assembly the ability to select any line that enters the shelter. This very powerful capability could be expanded to allow the computer, under operator direction, to systematically select lines that have been previously looped back at the far end and perform tests on them. The testing could be relatively simple, such as applying a tone to the send pair and observing that the tone is returned on the receive pair. If the Loopback were installed at the end of the cable that connects to the outside of the TSQ-84, it could then function as a cable tester. In this way during emplacement, as each cable is connected to the TSQ-84, a Loopback connector could be temporarily placed on the end of each cable and the cables could be tested for continuity to insure that all of the cable pairs are good. After all the cables are tested and any defective pairs are either repaired, or flagged so they are known as bad pairs, the cables can be hooked up to their terminal equipment. A loopback can then be performed at the terminal equipment, allowing the computer to run a test on the group of circuits going through that terminal equipment; i.e., (multiplexer and/or radio). This would then verify which circuits do have full duplex performance.

By using a system of progressively moving the loopback further and further from the central site, one piece of equipment after another can be tested until finally the loopback is being performed at the remote end radio park insuring all radio links, all multiplexers, all modems and all cables are actually operational. To perform this sort of a test, would require relatively simple changes in hardware and a very modest programing effort. As more experience is gained in the testing phase, it would certainly be worth considering this possibility.

5.3 CONCLUSIONS

In general, TSQ-84A has performed up to and in many cases beyond expectations. During the initial design phase, there were many questions relating to exactly what the development should perform. In the course of various discussions, the specification evolved into its present form. The only question that remains is whether there are other improvements which were not envisioned at that time, and/or other requirements that have since arisen. The purpose of the DT2/OT2 testing is to help resolve this sort of question. The design of the system is inherently flexible and was put together with full knowledge that there would be changes to the TSQ-84 in a conceptual as well as a practical sense in order to keep pace with the continually evolving Tactical and Defense Communications Systems.